MICROBIAL SCREENING, BIOREMIDIATION AND BIOENERGY GENERATION BY BACTERIAL FUEL CELLS FROM SEWAGE

Research Plan

For Registration for Ph.D. Programme

Submitted by

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1. INTRODUCTION

As the Environmental pollution is increasing day by day, environmental pollution has become unacceptable, as awareness of its effects on the environment has increased. Unfortunately, it is not possible to replace all the industrial processes generating polluting wastes with clean alternatives. Therefore, treatment both at source and after release must be considered as alternatives in many cases. Current research and recent waste management strategies have been emphasizing on waste minimization, recycling and remediation rather than disposal.

As the world population is unceasingly increasing, energy and water resources are becoming very limited. These problems are causing inflicting worries regarding global food safety for the primary time since the revolution of the 1960's (Gavrilescu, 2005). An extra challenge associated with the continues population in growth is that there is continuous increment in waste matter generation as well as environmental pollution. To record these extreme problems, some main advancement in research have been created which in result enhance the water management and to make wastewater treatment simpler and economical as well as powerful and efficient. Also, different types of renewable power energy sources (bioenergy, geothermal, solar, wind etc.) are investigated and applied (Li *et al.,* 2014).

It is marked that humankind is increasingly progressively based on energy with the development of science and technology. Increased economic population and social growth are the main cause to create a huge gap between electricity demands and the supply of fossil fuels. As the continuous human activities are increasing more and more natural electricity sources are being consumed resulting in depletion of the fossil fuels (Amann, 1996 and Das, 2001). In current situation the power scenario in India around the world is unpredictable, as the consequence riding to the search of other fossil fuels. Current strategies to produce energy are not ecological and economical and issues regarding change in climate and global warming require new strategies for energy generation using renewable and carbon sources.

The value of any energy-rich matters is continuously increasing in our society because of which the excessive biological load in wastewaters now is not seen as waste. Although physical and chemical methods have high efficiency but they need large investment and are easy to cause secondary pollution, while biological method has the advantages of low cost and without producing secondary pollution (Pant *et al.,* 2010). To exploit these biological substrates degradation, microbial fuel cells (MFCs) are developed for generation of electricity (Potter, 1911).

MFCs is a biochemical-catalysed device which generates electrical power through the decomposition of organic matter by the assistance of either bacteria or by the enzymes under slight reaction conditions (ambient temperature and pressure) (Logan, 2004). By the means of Microbial fuel cells (MFCs) the wastewater can be treated which provides a solution for water treatment and energy shortages by means of producing electricity i.e. MFC's is a powerful technology which produces the electrical energy by converting the potential energy during substrate oxidation via microorganisms (Kim *et al.,* 1999; Kim *et al.,* 2002; Park and Zeikus, 2000; Bond and Lovely, 2005; Liu *et al.,* 2004).

MFCs are acknowledged to be a popular method to produce energy from wastewater, providing a new way to concurrently to deal with wastewater at the same time as acquiring a supply of source of clean and renewable energy (Lui *et al.,* 2004; Min and Logan, 2004; Dental *et al.,* 2004; Tiehm *et al.,* 2001; Servrin-Reyssac, 1998; Ginkel *et al.,* 2005; Maekawa *et al.,* 1995).

Unlike few renewable strength assets opposing with food generation for land and water, MFC's will use organics in waste streams as power source and enhance food security via providing treated water that would be carried out in irrigation (Carole *et al*., 2016).

ADVANTAGES OF MFCs

MFCs have widespread advantages over the different technologies which are formerly used for the energy generation from organic matter.

- MFCs enable high conversion efficiency by direct conversion of substrate energy to electricity (Allen and Bennetto, 1993).
- MFCs operate efficiently at atmospheric temperature (Logan, 2004).
- MFCs do not require any energy input for aeration as the cathode is already aerated (Lui *et al.,* 2004).
- MFCs have significant application in the areas which are in need for electric infrastructures because it generates biofuels which satisfies the power requirements (Ra *et al.,* 2000).

The main aim of this work is to screen the degradation potential of sewage pollutants by efficient Bacterial fuel cells.

2. BRIEF LITERATURE REVIEW

Sewage is the water supply of the used water of community. It contains dilute water borne wastes from residence, business houses, industries etc. The chemical composition of sewage

water varies from day to day or even from hour. It also varies considerably between different sites, because the produce the wastes of different characters.

Sewage water contains inorganic wastes, that creates a problem of disposal, however other than inorganic wastes, few undesirable organic wastes that are hazardous are also present. Inorganic compounds of sewage water support the growth and expansion of harmful bacteria and different micro-organisms, that typically results in the epidemics among the people. It has been discovered that different types of serious diseases are spread by sewage.

Pathogenic microorganisms are almost always present in wastewater like 10^5-10^6 is the total coliform concentration present in the untreated waste water. This is because large number of pathogenic microorganisms may be excreted by infected individuals (Metcalf and Eddy, 1991)

Another study was done to analyse the performance of an MFC with multi anode/cathode arrangement towards removal of nutrients and solids, COD removal, BOD removal and cathode fouling using domestic wastewater as anodic fuel. As a result, it was concluded that 380 mW/m^2 (at the loading rate of 0.19-0.66 $kg/m^3/day$) of power density was generated by the reactor with 12 anodes/cathodes along with the removal of 80% of contaminants (at 8h hydraulic retention time) (Rabaey, 2005).

Puig *et al.,* 2006 demonstrated that, landfill leachates which was used for biofuel cells for treatment of organic matter (biodegradable) and production of electricity with very high content of nitrogen and salinity. From the results, it was concluded that total 8.5 $kgCODm^{-3}\ d^{-1}$ amount of organic matter was removed when the power density was 344 mWm^{-3}

In a method to improve cost effective substitute to Platinum catalyst, Zhang *et al.,* 2009 have established activated carbon air cathode. In his study, the cathode was fabricated by cold pressing activated carbon with polytetrafluoroethylene around a nickel mesh current collector. As a result, the 1220 mW/m^2 was generated as the maximum power density by carbon air cathode, which is relatively very higher than the platinum catalyst (1060 mW/m^2) and after that he concluded that the activated carbon-metal collector formed cathodes can be used as effective and economically feasible air cathodes in MFCs.

Kim *et al.,* 2010 with the help of Sediment-type microbial fuel cell (SMFC) concluded that Sediments organic carbon content is generally from 0.4% to 2.2% by weight. Thus, organic carbon content in sediments is sufficient for power generation source in some areas. These

materials can be consumed by exoelectrogens which directly transport the electrons outside of the cell.

Xia *et al.*, 2013 have developed an activated carbon cathode (Iron ethylene diamine tetra acetic acid) associated with a current collector which is made up of stainless steel. As a result, he found that the developed cathode produces power density (1580 ± 80 mW/m^2), which is very much higher (approximately ten percent) than normal activated carbon cathode.

MFC connected with anaerobic fluidized bed membrane reactor (MFC-AFBMR) of lab scale capacity was developed by Ren *et al.*, 2014 to report the issue of water quality from local (domestic) wastewater at least energy inputs. In his study, the system was run for 50 days continuously using local wastewater (Total COD 210 ± 11 mg/L) at normal temperature without any again and again washings of the membrane. From the study it was concluded that the MFC-AFBMR combined two stage system can generate high quality water from the local primary effluents even at slight atmospheric conditions, as the TSS were almost completely removed thereby, decreases the cost of the waste water treatment process.

In an another study carried out by Samsudeen *et al.*, 2015, a multi chamber MFC with four anode chambers and a cathode chamber was constructed wherein those chambers are separated by a skinny membrane. This study was carried out to beat the longer time required for addressing the huge amounts of wastewater and power generation. The MFC was constructed in such a way that all the four anodes and a cathode chamber were connected in a parallel lane so that they behave as individual cells. From the study, it was concluded that this type of setup of multi chamber MFC may be used for high power generation within a restricted area.

3. DESCRIPTION OF BROAD AREA/ TOPIC

The sewage from residential colonies as well effluent from industrial units has been identified as main cause for water pollution across our country. Sewage carries water waste either in suspended or solution form that has to be removed from the community. It is also known as wastewater as it contains high bacteriological organisms. During recent years, the awareness and concern about the water conservation has been increased all over the world. Hence, new approaches towards achieving sustainable development of water resources have been developed internationally. Wastewater itself is intrinsically rich in energy. While there are many technologies capable of extracting energy from sewage to offset the energy demand, Microbial fuel cells (MFCs) has seen the most widespread application as they are able to convert the potential energy directly into electrical energy.

4. OBJECTIVES OF THE STUDY/ PROBLEM IDENTIFICATION

Main objectives of present work will be:

- To collect different sewage samples from sewage treatment plant
- To characterize physico-chemical parameters of collected Sewage samples
- To study the microbial profile of the collected sewage samples by cultural, biochemical, molecular characterization for identification of bacterial isolates
- To prepare bacterial fuel cells from bacterial isolates
- To screen the degradation potential of sewage pollutants by efficient bacterial fuel cells

5. METHODOLOGY TO BE ADOPTED

5.1 **Sample Collection**

Sewage samples will be collected from STP's in Jaipur city (Rajasthan).

5.2 **To characterize physico-chemical parameters of collected Sewage samples**

All the collected sewage samples will be analysed physically with parameters, pH, Total Solids (TS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Electrical Conductance (EC) (Byung *et al.*, 2006).

5.3 **Microbial profiling of collected samples by cultural, biochemical, molecular characterization for identification of bacterial isolates**

After collection of samples, samples will be kept into the laboratory under aseptic conditions for further study on the basis of morphological, cultural, biochemical and molecular characterisation as below-

- Morphological & Cultural Characterisation
  - Size
  - Shape
  - Elevation
  - Colour
  - Temperature
  - Colony Characteristics
  - Growth Media etc.
- Biochemical Characterisation
  - Catalase Test
  - Indole Test

- Coagulase Test
- Oxidase Test
- Sugar Fermentation Test
- Carbohydrate Assimilation & Fermentation
- Cellulose Hydrolysis Test
- Nitrogen Assimilation etc.

(These tests will be modified according to protocol requirements)

- Molecular characterisation
  - 16S rRNA Gene Sequences

The isolates will be identified based on comparative analysis of the observed characteristics with the standard description of bacterial strains in Bergey's Manual of Determinative Bacteriology (Holt, 1986; Stanley, 1989; Cowan and Steels, 1974).

5.4 Preparation of Bacterial Fuel Cell

Bacterial Fuel Cells harness the conversion of bacterial energy to electrical energy (Potter, 1911). In BFCs, cathode and anode chamber will be prepared in which oxic conditions will be given to the cathode chamber and anoxic condition to the anode chamber. Then the abundant bacterial isolates will be subjected to fuel cells to identify their potential to treat or degrade the sewage sample. The best potent isolate will be used for the treatment of sewage and for the generation of energy (Logan *et al.*, 2010).

PROPOSED / EXPECTED OUTCOME OF THE RESEARCH

This research work will help us to understand the consortia of sewage and their potential to degrade the organic substances into inorganic substances with the help of Bacterial fuel cells. The outcome of this research will help us to generate the electricity from the potent microbes from the waste water.

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